

CLAIMS

What is claimed is:

5 1. A fluid treatment system comprising:
a light source for providing light; and
a flexible treatment chamber having an input port and an output port, at least a portion of the flexible treatment chamber positioned to receive the light;

10 the at least the portion of the flexible treatment chamber transmissive to at least 1% of the light having at least one wavelength within a range of 170 to 2600 nm;

15 the flexible treatment chamber adapted to allow a fluid to be treated to be flowed via the input port therethrough at a specified rate and out the output port,

wherein the light source illuminates the fluid as it flows through the flexible treatment chamber in order to deactivate pathogens within the fluid.

20 2. The system of Claim 1 wherein the flexible treatment chamber is made of a light transmissive plastic material.

25 3. The system of Claim 1 further comprising a light transmissive window that supports the flexible treatment chamber and defines at least one dimensional boundary of a treatment zone of the flexible treatment chamber.

30 4. The system of Claim 1 further comprising a first support structure positioned in between the light source and the flexible treatment chamber, the first support structure transmissive to at least a portion of the light.

5. The system of Claim 4 further comprising a second support structure positioned to hold the flexible treatment chamber in between the second support structure and the first support structure.

5 6. The system of Claim 1 further comprising a rigid cartridge for holding the flexible treatment chamber in position and defining at least one dimensional boundary of a treatment zone of the flexible treatment chamber.

10 7. The system of Claim 6 further comprising a cartridge registration plate, wherein the rigid cartridge is held in position by the cartridge registration plate.

15 8. The system of Claim 1 further comprising a first support structure and a second support structure restraining the flexible treatment chamber therebetween.

20 9. The system of Claim 8 wherein the distance between the first support structure and the second support structure is adjustable.

25 10. The system of Claim 8 further comprising a spacer positioned between the first support structure and the second support structure defining a distance between the first support structure and the second support structure.

30 11. The system of Claim 1 further comprising a first process monitor for measuring the light emitted directly from the light source.

 12. The system of Claim 11 further comprising a second process monitor positioned such that at least a portion of the treatment chamber is in between the second process monitor and the light source, the second process

monitor for measuring light penetrating through the flexible treatment chamber.

5 13. The system of Claim 12 wherein one or more of the first process monitor and the second process monitor comprise an optical detector selected from a group consisting of: a photodetector, a photodiode, a fiber optic probe, a calorimeter, a joulemeter, a photomultiplier tube, a camera, and a CCD array.

10 14. The system of Claim 12 wherein one or more of the first process monitor and the second process monitor comprise a thermodetector selected from a group consisting of: a thermocouple, a thermopile, a calorimeter, and a joulemeter.

15 15. The system of Claim 1 wherein the light source comprises a pulsed light source that provides pulses of light.

20 16. The system of Claim 1 further comprising an actuator assembly coupled to the flexible treatment chamber for flowing the fluid through the flexible treatment chamber at the specified flow rate.

 17. The system of Claim 1 further comprising a fluid container containing the fluid to be treated and coupled to the flexible treatment chamber.

25 18. The system of Claim 1 wherein the flexible treatment chamber comprises a bag-like structure, the fluid to be flowed therethrough.

19. A light treatment system for treating fluid products comprising:

a light source for providing light;

5 a treatment chamber positioned to receive the light and for allowing the fluid products to be flowed therethrough; and

a support structure supporting the treatment chamber and defining at least one dimensional boundary of a treatment zone of the treatment chamber, at least a portion of the treatment chamber and at least a portion of the support structure being transmissive to at least 1% of the light
10 having at least one wavelength within a range of 170 to 2600 nm;

wherein the light source illuminates the fluid products as they flow through the treatment chamber in order to deactivate pathogens within the fluid products.

20. The system of Claim 19 wherein the support structure comprises:

a light transmissive window positioned between the light source and the treatment chamber; and

a plate positioned to support the treatment chamber between
20 the plate and the light transmissive window.

21. The system of Claim 20 wherein the light transmissive window comprises a flat light transmissive window and the plate comprises a flat plate.

22. The system of Claim 19 further comprising a flow chamber formed within the treatment chamber, the fluid products flowing through the flow chamber, wherein the support structure restrains the flow chamber to define the at least one dimensional boundary of the treatment zone while the
30 fluid products are flowed therethrough.

23. The system of Claim 22 wherein the flow chamber substantially conforms to the dimensions of at least one side of the volume created for the treatment chamber by the support structure.

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24. The system of Claim 22 further comprising means to control the restraintment of the flow chamber in order to control the thickness of the treatment zone.

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25. The system of Claim 19 further comprising at least one spacer coupled to the support structure for defining a thickness of the treatment zone.

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26. The system of Claim 19 wherein the support structure comprises a cartridge, the treatment chamber positioned within the cartridge.

27. The system of Claim 19 wherein the treatment chamber comprises a flexible treatment chamber.

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28. A disposable light treatment chamber comprising:
a flexible flow chamber transmissive to at least 1% of a light treatment having at least one wavelength within a range of 170 to 2600 nm, the flexible flow chamber adapted to allow a fluid to be flowed therethrough and illuminated with the light treatment such that pathogens within the fluid are deactivated by the light treatment;

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an input port formed at one part of the flexible flow chamber and adapted to receive a flow of the fluid to be treated; and

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an output port formed at another part of the flexible flow chamber adapted to receive the flow of the fluid having been treated with the light treatment.

29. The chamber of Claim 28 further comprising a flexible body portion, the flow chamber formed within the flexible body portion.

5 30. The chamber of Claim 29 wherein the flexible body portion is substantially flat.

31. The chamber of Claim 30 wherein the flexible body portion and the flexible flow chamber comprise two or more sheets of light
10 transmissive material attached together, the flexible flow chamber formed between a portion of the two or more sheets of the light transmissive material.

32. The chamber of Claim 28 wherein the flexible flow chamber is comprised of a light transmissive plastic material.
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33. The chamber of Claim 28 wherein the flexible flow chamber is comprised of a light transmissive material selected from a group consisting of: a polyolefin, a fluorinated polymer, a halogenated polymer, a nylon, and combinations thereof.
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34. The chamber of Claim 28 wherein the flexible flow chamber is comprised of a light transmissive material selected from a group consisting of: FEP (fluorinated ethylene-propylene perfluoro (ethylene-propylene)), EVA (ethylene vinyl acetate), PTFE (polytetrafluoroethylene), PFA (perfluoro
25 (alkoxy alkane)), ethyl vinyl alcohol, polyvinylidene fluoride (PVDF), polyvinylidene chloride (PVDC): Saran, and polyamides, such as nylon and polychlorotrifluoroethylene (PCTFE): Aclar.

35. The chamber of Claim 28 wherein the flow chamber is
30 substantially flat without the fluid flowed therethrough and wherein the fluid

expands the flow chamber as the fluid flows therethrough.

36. The chamber of Claim 28 wherein the flexible flow chamber is adapted to be restrained between two support structures on either side of the flexible flow chamber.

37. The chamber of Claim 28 wherein the disposable treatment chamber is designed to be used once and discarded.

38. The chamber of Claim 28 wherein the input port has a substantially circular cross sectional profile and the flexible flow chamber has a substantially flat cross sectional profile, the chamber further comprising:
a taper section formed between the input port and the flexible flow chamber, wherein the taper section is shaped to transition a substantially circular fluid flow profile into a substantially flat fluid flow profile such that the fluid flow through the flexible flow chamber is substantially laminar having approximately the same fluid flow velocity across the profile of the flexible flow chamber.

39. A light treatment device to be illuminated with light for deactivating pathogens within fluid products comprising:
a cartridge body comprising a first part and a second part;
a first light transmissive window of the first part;
a flexible treatment chamber positioned against the first light transmissive window, wherein at least a portion of the flexible treatment chamber is transmissive to at least 1% of the light having at least one wavelength within a range of 170 to 2600 nm, wherein fluid to be treated with the light flows through the flexible treatment chamber; and
a plate portion of the second part, the plate portion positioned against the flexible treatment chamber, wherein the plate portion restrains the

flexible treatment chamber against the first light transmissive window in order to define at least one dimensional boundary of a fluid flow path for the fluid within the flexible treatment chamber.

5 40. The device of Claim 39 wherein the flexible treatment chamber comprises:

 a flexible body portion;

 an input port formed in the flexible body portion;

 an output port formed in the flexible body portion; and

10 a flexible flow chamber formed within the flexible body portion and coupled to the input port and the output port, wherein the flexible flow chamber is transmissive to light, wherein fluid to be treated with light flows through the input port, the flexible flow chamber and the output port, the flexible flow chamber being restrained between the first light transmissive
15 window and the plate portion.

 41. The device of Claim 39 wherein the plate portion comprises a second light transmissive window.

20 42. The device of Claim 39 wherein the first light transmissive window comprises a first flat light transmissive window and the plate portion comprises a flat plate portion.

25 43. The device of Claim 39 further comprising at least one spacer positioned between the first part and the second part such that the plate portion and the first light transmissive window are separated by a specified distance.

30 44. The device of Claim 39 wherein the flexible treatment chamber includes at least one alignment feature.

45. The device of Claim 44 wherein a respective one of the at least one alignment feature is coupled to a respective corresponding alignment feature coupled to one or more of the first part and the second part.

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46. A method of fluid decontamination comprising:
flowing a fluid product through a flexible treatment chamber,
the flexible treatment chamber being light transmissive to at least 1% of a light
treatment having at least one wavelength within a range of 170 to 2600 nm;

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illuminating the fluid product with the light as the fluid product
is flowed through the flexible treatment chamber; and

deactivating pathogens within the fluid product.

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47. The method of Claim 46 wherein the fluid product
comprises a biological fluid including at least one protein.

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48. The method of Claim 47 wherein the illuminating step
results in a protein damage to kill ratio of less than 5, wherein the protein
damage to kill ratio is defined as a percentage of protein activity reduction
after the illuminating step divided by the log reduction of the pathogens.

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49. The method of Claim 46 wherein the illuminating step
comprises illuminating the fluid product with pulses of light.

50. The method of Claim 49 wherein the illuminating step
comprises illuminating the fluid product with the pulses of light having
wavelengths within a spectral range of at least between 240 nm and 280 nm
and having a pulse duration of less than 100 ms.

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51. The method of Claim 49 wherein the illuminating step

comprises illuminating the fluid product with the pulses of light having a fluence greater than 0.001 J/cm².

52. The method of Claim 49 wherein the illuminating step
- 5 comprises illuminating the fluid product with the pulses of light, wherein at least 0.5% of the fluence of the pulses of light is concentrated at wavelengths within a range of 200 nm to 320 nm.

53. The method of Claim 46 wherein the flowing step comprises
- 10 flowing the fluid product through the flexible treatment chamber at a constant flow rate.